definitional restrictions in CIS with respect to innovation inputs and outputs, and on whether an approach that was originally adopted for manufacturing is extendable to services. On the output side, the decisions made concerning the technological definitions of change obviously limit the forms of innovation that can be studied: it seems to be the case that CIS works well for manufactures, but not for the extremely heterogeneous services sector and its often intangible outputs. The analyses of Djellal and Gallouj (2001) and Tether and Miles (2001) suggest the need for quite different approaches to data gathering on services. In defence of the CIS approach it can be argued that it is, and was intended to be, manufacturing-specific and that extension to services would always be problematic. Similar problems arise with other non-technological aspects of innovation, such as organizational change (see Lam, this volume, for an overview of organizational innovation). It is very unclear whether CIS, or indeed any other survey-based method, can grasp the dimensions of this. The challenge for those who would go beyond this is whether they can generate definitional concepts, survey instruments, and collection methodologies that make sense for other sectors or other aspects of innovation.

On the side of R&D and non-R&D innovation inputs, it is generally unclear just how much of a firm's creative activity is captured by the types of innovation outputs that CIS measures. Arundel has pointed out that "When we talk about a firm expending a great deal of effort on innovation, we are not only speaking of financial investments, but of the use of human capital to think, learn and solve complex problems and to produce qualitatively different types of innovations" (Arundel 1997: 6). This point cannot be argued with, but again the question arises as to what can be done with survey questionnaires and what cannot. If we want to explore complex problem solving, for example, then it is doubtful whether a survey instrument is the right research tool at all. Perhaps an underlying issue here is the long-standing tension between statistical methods, with their advantages of generality but lack of depth, versus case study methods, which offer richness at the expense of generalizability.

Nevertheless it is reasonable to conclude that this data source is proving itself with researchers. Both formal evaluations of CIS as well as data tests by researchers have been broadly positive to the quality of the data flowing from the survey (Aalborg University 1995). One of the positive features of CIS is that survey definition and construction, collection methodologies, and general workability have been subjected to a degree of evaluation, critique, and debate that goes far beyond anything that has been carried out with other indicators (see Arundel et al. 1997, for one contribution to the critical development of CIS). This process is continuing, with both positive and negative potential outcomes. On the positive side, the data source may continue to be improved; on the negative, too much may be asked of this approach. But the real achievement is that CIS has produced results that have not been possible with other data sources, and there is no doubt more to come as researchers master the intricacies of the data. In fact empirical studies using CIS data may well be the most rapidly growing sub-field of publication within innovation studies at the present time. An interesting feature of the publications using CIS is the breadth of work being done—the data is being used for public presentations, for policy analyses, and for a wide range of scholarly research. It was argued above that researchers have yet to make full use of the richness of R&D data, and this applies even more to the existing survey-based innovation data. This source will continue to offer considerable scope to researchers in years ahead: issues such as innovation and firm performance, the use of science by innovating firms, the roles of non-R&D inputs, and the employment impacts of innovation are among likely areas of development.

This chapter has concentrated on the Community Innovation Survey, but future developments are unlikely to rely on this source alone. One possible trend is for greater integration of existing data sources, and this can already be seen in multi-indicator approaches to such issues as national competitiveness. Another likely trend is for the continued development of new survey instruments aligned to specific needs, along the lines of the DISKO surveys on interfirm collaboration (OECD, 2001). Such developments are much to be welcomed as Innovation Studies seeks to generalize its propositions beyond the limits of the case study method.

APPENDIX 6.1

Recent (2002 onwards) journal publications using CIS data

Author(s)	Data source	Topic
Cox, Frenz, and Prevezer (2002)	CIS-2	Distinguishing high- and low-tech industries
Evangelista and Savona (2002)	CIS 1 and 2	Employment impacts of innovation in service sector
Hesselman (2002)	CIS-2	Methodological issues and response patterns
Hinloopen (2003)	CIS-1 and CIS-2	Determinants of innovation performance at firm level across Europe
Inzelt (2002)	CIS-2	Service sector innovation in Hungary
Kleinknecht et al (2002)	CIS-2	Indicator choice and biases
Lööf and Heshmati (2004)	CIS-2	Innovation and firm performance
Lööf and Heshmati (2002)	CIS-2	Performance diversity and innovation

Mairesse and Mohnen	CIS-1	Determinants of innovation at firm level
Mohnen and Horeau (2003)	CIS-2	University-industry collaboration
Mohnen, Mairesse, and Dagenais (2003)	CIS-1	Expected vs. actual innovation output levels
Nascia and Perani (2002)	CIS-1	Diversity of innovation patterns in Europe
Quadros et al. (2001)	Brazilian innovation survey	Innovation in San Paulo region
Sellenthin and Hommen (2002)	CIS-2	Innovation patterns in Swedish industry
Tether (2002)	CIS-2	Innovation and inter-firm collaboration
Tether and Swann (2003)	CIS-3	Role of science in innovation
Van Leeuwen and Klomp (2004)	CIS-2	Innovation and multi-factor productivity

APPENDIX 6.2

Publications using CIS data sponsored by the European Commission

Publications are listed in chronological order, by topic and instituion.

Evaluation of the Community Innovation Survey (CIS)—Phase 1,
Aalborg University (Denmark), 1995

Europe's Pharmaceutical Industry: An Innovation Profile (CIS),
SPRU (UK), 1996

Innovation Outputs in European Industry (CIS),
SPRU (UK), 1996

Innovation in the European Food Products and Beverages Industry (CIS),
IKE (Denmark) and SPRU (UK), 1996

Technology Transfer, Information Flows and Collaboration (CIS),
Manchester School of Management & University of Warwick (UK), 1996

The Impact of Innovation on Employment: Alternative interpretations and results of the Italian CIS,
University of Rome "La Sapienza" (Italy), 1996

Innovation in the European Chemical Industry (CIS),
WZB (Germany) 1996

Publications are listed in deronological order, by topic and instituion. (cont.)

Innovation in the European Telecom Equipment Industry (CIS),
MERIT (Netherlands), 1996

Innovation Activities in Pulp, Paper and Paper Products in Europe (CIS),
STEP Group (Norway), 1996

The Impact of Innovation in Employment in Europe—An Analysis Using CIS Data,
Centre for European Economic Research/ZEW (Germany), 1996

Computer and Office Machinery—Firms' external growth & technological diversification: analysis during CIS,
CESPRI (Italy) 1997

Innovation Expenditures in European Industry: analysis from CIS,
STEP Group (Norway), 1997

Manufacture of Machinery and Electrical Machinery (CIS),
Centre for European Economic Research/ZEW (Germany), 1997

Innovation Measurements and Policies: Proceedings of International Conference,
20–21 May 1996, Luxembourg

Analysis of CIS 2 Data on the Impact of Innovation on the Pharmaceuticals and Biotechnology Sector,
SOFRES (Belgium), 2001

Analysis of CIS 2 Data on the Impact of Innovation on Growth in the Sector of Office Machinery and Computer Manufacturing,
SOCINTEC (Spain), 2001

Analysis of CIS 2 Data on the Impact of Innovation on Growth in Manufacturing of Machinery and Equipment and of Electrical Equipment,
STEP Group (Norway), 2001

Analysis of CIS Data on the Role of NTBFs, Spin-offs and Innovative Fast Growing SMEs in the Innovation Process,
Institute for Advanced Studies and Johanneum Research (Austria), 2001

Innovation and the Acquisition and Protection of Competencies,
MERIT (Netherlands), 2001

Analysis of Empirical Surveys on Organisational Innovation and Lessons for Future Community Innovation Surveys,
Fraunhofer Institute (Germany), 2000

Regional Patterns of Innovation: the Analysis of CIS 2 Results and Lessons from other Innovation Surveys,
STEP S.A.S (Italy), 2000

Use of Multivariate Techniques to Investigate the Multidimensional Aspects of Innovation,
University of Newcastle Upon Tyne (ISRU) (UK), 2000

Statistics on Innovation in Europe,
European Commission, 2001

Analysis of CIS 2 Data on Innovation in the Service Sector,
Manchester University (UK), 2000

"Innovation and enterprise creation: Statistics and indicators," Proceedings of the International Conference, 23

NOTES

1. I would like to thank Ian Miles, Bart Verspagen, and Richard Nelson for comments on an earlier draft, and in particular Bronwyn Hall for comments and advice. None are implicated in the outcome, of course.
2. The question of what can be measured is an issue with all economic statistics. For example, the national accounts do not cover all economic activity (in the sense of all human activity contributing to production or material welfare). They incorporate only activity that leads to a measurable market outcome or financial recompense. This tends to leave out economic activity such as domestic work, mutual aid, child rearing, and the informal economy in general. Those services that are measured not by the value of output but by the compensation of inputs also provide problems for measurement of output and productivity.
3. In both Australia and Norway, each of which collects data by field of research for all industrial sectors, roughly 25 per cent of all R&D is in ICT.
4. An excellent overview of the literature on these and other patent issues can be found on the website of Bronwyn Hall: http://emlab.berkely.edu/users/bhhall See also Granstrand in this volume.
5. For analyses using the SPRU database, see e.g. Pavitt 1983, 1984; Robson et al. 1988; the most recent sustained analytical work using the SPRU database is Geroski 1994.
6. Canada is a leading site of policy-related indicator work at the present time—see e.g. the outstanding work of the Canadian Science and Innovation Indicators Consortium which can be found at the website given above.
7. On innovation in low-tech industries, see Ch. 15 by von Tunzelmann and Acha in this volume.

REFERENCES

AALBORG UNIVERSITY (1995), *Evaluation of the Community Innovation Survey (CIS)—Phase 1*, 2 vols., Report to the European Innovation Monitoring System.

ACS, Z., and AUDRETSCH, D. (1990), *Innovation and Small Firms*, Cambridge, Mass: MIT Press.

*ARCHIBUGI and PIANTA (1996), "Innovation surveys and patents as technology indicators: the state of the art," in OECD, *Innovation, Patents and Technological Strategies*, Paris: OECD.

ARROW, K. J. (1984), "Statistical Requirements for Greek Economic Planning," *Collected Papers of Kenneth J. Arrow*, vol. 4: *The Economics of Information*, Oxford: Blackwell.

ARUNDEL, A. (1997), "Why Innovation Measurement Matters," in A. Arundel and R. Garrelfs (eds.), *Innnovation Measurement and Policies*, EU Luxembourg: EIMS 94/197.

ARUNDEL, A., PATEL, P., SIRILLI, G., and SMITH, K. (1997), *The Future of Innovation Measurement in Europe: Concepts, Problems and Practical Directions*, IDEA Paper No 3, STEP Group Oslo.

* Asterisked items are suggestions for further reading.

Biffl, G., and Knell, M. (2001), "Innovation and Employment in Europe in the 1990s," *WIFO Working Paper* 169/2001.

Brouwer, E., and Kleinknecht, A. (1997), "Measuring the Unmeasurable: A Country's Expenditure on Product and Service Innovation," *Research Policy* 25: 1235–42.

—— —— (1999), "Innovative Output and a Firm's Propensity to Patent: An Exploration of CIS Micro-Data," *Research Policy* 28: 615–24.

Cox, H., Frenz, M., and Prevezer, M. (2002), "Patterns of Innovation in UK Industry: Exploring the CIS Data to Contrast High and Low Technology Industries," *Journal of Interdiciplinary Economics* 13(1–3): 267–304.

*Djellal, F., and Gallouj, F. (2001), "Innovation surveys for Service Industries: A Review," in Thurieaux, Arnold, and Couchot 2001: 70–6.

Dowrick, S. (2003), "A Review of the Evidence on Science, R&D and Productivity," Working Paper, Department of Economics, Australian National University.

European Commission (1994), *The European Report on Science and Technology Indicators 1994* (EUR 15897), Luxembourg.

—— (1997), *Second European Report on Science and Technology Indicators 1997* (EUR 17639), Luxembourg.

European Commission (2001), Statistics on Innovation in Europe (EUR KS-32-00-895-EN-1), Luxembourg.

—— (2003), *Third European Report on Science and Technology Indicators*, Luxembourg.

eurosrat (2004), *Innovation in Europe. Results for the EU, Iceland and Norway: Data 1998–2001*, (Luxembourg: Office for one official publications of the European Communities)

—— Sandven, T., Sirilli, G., and Smith, K. (1998), "Measuring Innovation in European Industry," *International Journal of the Economics of Business* 5(3): 311–33.

—— and Savona, M. (2002), "The Impact of Innovation on Employment in Services: Evidence from Italy," *International Review of Applied Economics* 16(3): 309–18.

Evangelista, R. (1999), *Knowledge and Investment*, Cheltenham: Edward Elgar.

Gault, F. (ed.) (2004), *Understanding Innovation in Canadian Industry*, Montreal and Kingston: McGill-Queen's University Press.

Geroski, P. (1994), *Market Structure, Corporate Performance and Innovative Activity*, Oxford: Clarendon Press.

Godin, B. (2004), "The Obsession with Competitiveness and its Impact on Statistics: The Construction of High Technology Indicators," *Research Policy* (forthcoming).

Griffith, R., Redding, S., and Van Reenen, J. (2000), "Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries," *LSE Centre for Economic Performance Discussion Paper*, 2457: 1–74.

Griliches, Z. (1987), "Comment," Washington, DC: Brookings Papers on Economic Activity, 3.

Grupp, H. (1994), "The Measurement of Technical Performance of Innovations by Technometrics and its Impact on Established Technology Indicators," *Research Policy* 23: 175–93.

*—— (1998), *Foundations of the Economics of Innovation, Theory, Measurement and Practice*, Cheltenham: Elgar.

Guellec, D., and Pattinson, B. (2001), "Innovation Surveys: Lessons from OECD Countries' Experience," *STI Review* 27: 77–102.

Hagedoorn, K., and Schakenraad, J. (1990), "Inter-firm Partnerships and Co-operative Strategies in Core Technologies," in C. Freeman and L. Soete (eds.), *New Explorations in the Economics of Technological Change*, London: Pinter.

HALL, B. H. and Ziedonis, R. H. (2002), "The determinants of patenting in the U.S. semiconductor industry, 1980–1994", *Rand Journal of Economics*, 32: 101–28.

——, Jaffe, A., and Trajtenberg, M., 2001, "The NBER Patent Citations Daa file: Lessons, Insights and Methodological Tools", NBER Working Paper No. 8498.

*HANSEN, J. A. (2001), "Technological Innovation Indicators: A Survey of Historical Development and Current Practice," in M. P. Feldmann and A. Link (eds.), *Innovation Policy in the Knowledge-Based Economy*, Dordrecht: Kluwer, 73–103.

HESSLEMAN, L. (2002), "A Description of Responses to the UK Community Innovation Survey 2," *The Journal of Interdiciplinary Economics* 13(1–3): 243–66.

HINLOOPEN, J. (2003), "Innovation Performance across Europe," *Economics of Innovation and New Technology* 12(2): 145–61.

HIRSCH-KREINSEN, H., JACOBSEN, D., LAESTADIUS, S., and SMITH, K. (2003), "Low Tech Industries and the Knowledge Economy: State of the Art and Research Challenges," *Working Paper 2003:10*, Dept of Industrial Economics and Management, Royal Institute of Technology (KTH), Stockholm.

HOLBROOK, J. (1991), "The Influence of Scale Effects on International Comparisons of R&D Expenditure," *Science and Public Policy* 18(4): 259–62.

HOWELLS, J. (2000), "Innovation Collaboration and Networking: A European Perspective," in Science Policy Support Group, *European Research, Technology and Development. Issues for a Competitive Future*, London.

HUGHES, K. (1988), "The Interpretation and Measurement of R&D Intensity: A Note," *Research Policy* 17: 301–7.

INZELT, A. (2002), "Attempts to Survey Innovation in the Hungarian Service Sector," *Science and Public Policy* 29(5): 367–83.

IVERSEN, E. (1998), "Patents," in K. Smith (ed.), *Science, Technology and Innovation Indicators—a Guide for Policymakers*, IDEA Report 5, STEP Group Oslo.

JAFFE, A., and Henderson, R., and Trajtenberg, M., 1997, "University Versus Corporate Patents: A Window on the Basicness of Invention", *Economics of Innovation and New Technology*, 19–50.

JANZ, N., et al. (2002), *Innovation Activities in the German Economy. Report on Indicators from the Innovation Survey 2000*, Mannheim: ZEW.

KALOUDIS, A. (1998), "Bibliometrics," in K. Smith (ed.), *Science, Technology and Innovation Indicators—a Guide for Policymakers*, IDEA Report 5, STEP Group Oslo.

*KLEINKNECHT, A. (ed.) (1996), *Determinants of Innovation: The Message From New Indicators*, London: Macmillan.

—— and BAIN, D. (eds.) (1993), *New Concepts in Innovation Output Measurement*, London: Macmillan.

—— and MOHNEN, P. (eds.) (2002), *Innovation and Firm Performance. Econometric Explorations of Survey Data*, Hampshire and New York: Palgrave.

—— VAN MONTFORT, K., and BROUWER, E. (2002), "The Non-Trivial Choice Between Innovation Indicators," *Economics of Innovation and New Technology* 11(2): 109–21.

KLINE, S., and ROSENBERG, N. (1986), "An Overview of Innovation," in R. Landau (ed.), *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, Washington: National Academy Press, 275–306.

KORTUM, S., and LERNER, J. (1999), "What is Behind the Recent Surge in Patenting?" *Research Policy* 28: 1–22.

LAESTADIUS, S. (2003), "Measuring Innovation in the Knowledge Economy," Paper presented to Pavitt Conference on Innovation, SPRU, Sussex, 13 Nov 2003.

LÖÖF, H., and HESHMATI, A. (2002), "Knowledge Capital and Performance Heterogeneity: A Firm-Level Innovation Study," *International Journal of Production Economics* 76(1): 61–85.

—— —— (2004), "On the Relationship between Innovation and Performance: A Sensitivity Analysis," *Economics of Innovation and New Technology* 13(1–2): forthcoming.

MCLEOD, C. (1988), *Inventing the Industrial Revolution: The English Patent System, 1660–1800*, Cambridge: Cambridge University Press.

MAIRESSE, J., and MOHNEN, P. (2001), "To be or not to be Innovative: An Exercise in Measurement," *STI Review* 27: 103–28.

*—— —— (2002), "Accounting for Innovation and Measuring Innovativeness: An Illustrative Framework and an Application," *American Economic Review* 92(2): 226–30.

*MEYER, M. (2000), "Does Science Push Technology? Patents Citing Scientific Literature," *Research Policy* 29: 409–34.

MOED, H. F., DE BRUIN, R. E., and VAN LEEUWEN, Th. N. (1995), "New Bibliometric Tools for the Assessment of National Research Performance: Database Description, Overview of Indicators and First Application," *Scientometrics* 33: 381–422.

MOHNEN, P., and HOAREAU, C. (2003), "What Types of Enterprise Forge Close Links with Universities and Government Labs? Evidence from CIS-2," *Managerial and Decision Economics* 24: 133–45.

—— MAIRESSE, J., and DAGENAIS, M. (2004), "Innovativeness: A Comparison across Seven European Countries," *Economics of Innovation and New Technology* 13(1–2): forthcoming.

NARIN, F., and NOMA, E. (1985), "Is Technology Becoming Science?" *Scientometrics* 3–6: 369–81.

NASCIA, L., and PERANI, G. (2002), "Diversity of Innovation in Europe," *International Review of Applied Economics* 16(3): 277–94.

OECD (1992, rev. 1997), *Innovation Manual: Proposed Guidelines for Collecting and Interpreting Innovation Data (Oslo Manual)*, Paris: OECD, Directorate for Science, Technology and Industry.

—— (1996), *Technology, Productivity and Job Creation*, Paris: OECD.

—— (2001), *Innovating Networks: Collaboration in National Innovation Systems*, Paris: OECD.

—— (2002), *The Measuerment of Scientific and Technological Actvities. Proposed Standard Practice for Surveys on Research and Experimetnal Development: Frascati Manual*, Paris: OECD.

PATEL, P., and PAVITT, K. (1997), "The Technological Competencies of the World's Largest Firms, Complex and Path-Dependent, but not Much Variety," *Research Policy* 26: 141–56.

*—— —— (1999), "The Wide (and Increasing) Spread of Technological Competencies in the World's Largest Firms: a Cahllenge to Conventional Wisdom," in A. Chandler et al. (eds.), *The Dynamic Firm: The Role of Technology, Strategy, Organization and Regions*, Oxford: Oxford University Press.

PAVITT, K. (1983), "Some Characteristics of Innovation Activities in British Industry," *Omega* 11.

*—— (1984), "Sectoral Patterns of Technological Change: Towards a Taxonomy and a Theory," *Research Policy* 13: 343–73.

POL, E., CARROLL, P., and ROBERTSON, P. (2002), "A New Typology for Economic Sectors with a View to Policy Implications," *Economics of Innovation and New Technology* 11(1): 61–76.

Quadros, R., Furtado, A., Bernades, R., and Eliane, F. (2001), "Technological Innovation in Brazilian Industry: An Assessment Based on the San Paulo Innovation Survey," *Technological Forecasting and Social Change* 67: 203–19.

Robson, M., Townsend, J., and Pavitt, K. (1988), "Sectoral Patterns of Production and Use of Innovations in the UK: 1945–1983," *Research Policy* 17(1): 1–15.

Rosenberg, N. (1976), *Perspectives on Technology*, Cambridge: Cambridge University Press.

—— (1982), *Inside the Black Box: Technology and Economics*, Cambridge: Cambridge University Press.

Sandven, T., and Smith, K (1997), "Understanding R&D Indicators: Effects of Differences in Industrial Structure and Country Size," IDEA Paper 14, STEP Group Oslo.

Saviotti, P. P. (1996), *Technological Evolution, Variety and the Economy*, Cheltenham: Elgar.

—— (2001), "Considerations about a Production System with Qualitative Change," in J. Foster and J. Stanley Metcalfe (eds.), *Frontiers of Evolutionary Economics. Competition, Self-Organization and Innovation Policy*, Aldershot: Edward Elgar, 197–227.

Scherer, F. (1982), "Inter-industry Technology Flows in the United States," *Research Policy* 11(4): 227–45.

Schmookler, J. (1971), "Economic Sources of Inventive Activity," in N. Rosenberg (ed.), *The Economics of Technological Change*, London: Pelican, 117–36.

Sellenthin, M., and Hommen, L. (2002), "How Innovative is Swedish Industry? A Factor and Cluster Analysis of CIS II," *International Review of Applied Economics* 16(3): 319–32.

Smith K. (1992), "Technological Innovation Indicators: Experience and Prospects," *Science and Public Policy* 19(6): 24–34.

—— (2001), "Innovation Indicators and the Knowledge Economy: Concepts, Results and Challenges," in Thurieaux, Arnold, and Couchot (eds), Luxembourg: European Commission, 14–25.

SPRU (1996), *Innovation Outputs in European Industry (CIS)*, Report to the European Innovation Monitoring System.

STEP Group (1997), *Innovation Expenditures in European Industry: Analysis from CIS*, Report to the European Innovation Monitoring System.

Sullivan, R. (1990), "The Revolution of Ideas: Widespread Patenting and Invention During the Industrial Revolution", *Journal of Economic History* 50(2): 340–62.

Tether, B. (2002), "Who Cooperates for Innovation and Why: An Empirical Analysis," *Research Policy* 31(6): 947–67.

—— and Miles, I. (2001), "Surveying Innovation in Services—Measurement and Policy Interpretation Issues," in Thurieaux, Arnold, and Couchot (2001).

—— and Swann, G. M. P. (2003), "Services, Innovation and the Science Base: An Investigation Into the UK's 'System, of Innovation' Using Evidence from the Third Community Innovation Survey," paper to CNR/Univerity of Urbino Workshop on Innovation In Europe.

*Thurieaux, B., Arnold, E., and Couchot, C. (eds.) (2001), *Innovation and Enterprise Creation: Statistics and Indicators*, Luxembourg: European Commission (EUR 17038).

Van Leeuwen, G., and Klomp, L. (2004), "On the Contribution of Innovation to Multifactor Productivity," *Economics of Innovation and New Technology* 13(1–2): forthcoming.

Verspagen, B. (1992), "Endogenous Innovation in Neo-classical Growth Models: A Survey," *Journal of Macroeconomics* 631–62.

World Economic Forum (2003), *Global Competitiveness Report 2002–2003*, ed. P. Cornelius, K. Schwab, and M. E. Porter, New York: Oxford University Press.